

Exploring Hadriacus Palus: A Record of Diverse Geologic Processes in the Cratered Highlands

NOTE ADDED BY JPL WEBMASTER: This content has not been approved or adopted by, NASA, JPL, or the California Institute of Technology. This document is being made available for information purposes only, and any views and opinions expressed herein do not necessarily state or reflect those of NASA, JPL, or the California Institute of Technology.

Second Landing Site Workshop for the Mars 2020 Rover Mission August 4-6, 2015

J. A. Skinner, Jr.¹, C. M. Fortezzo¹, T. M. Hare¹, and T. Platz^{2,3}

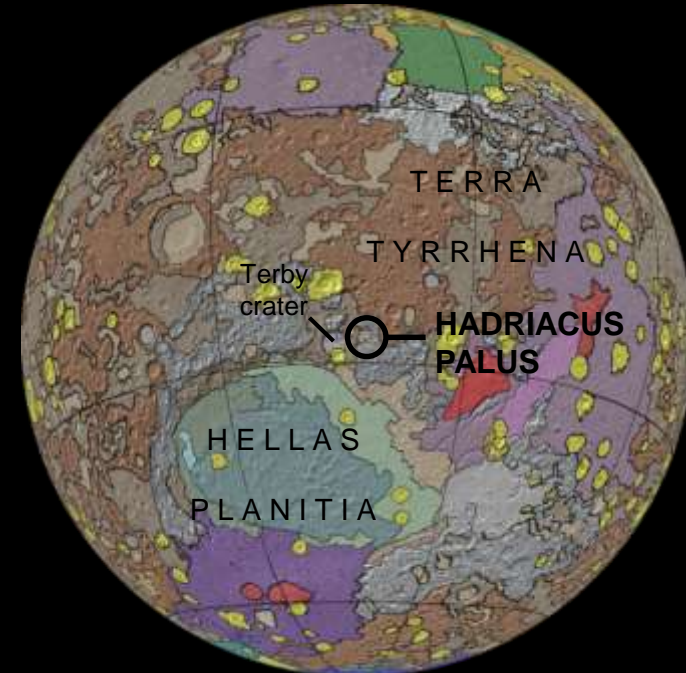
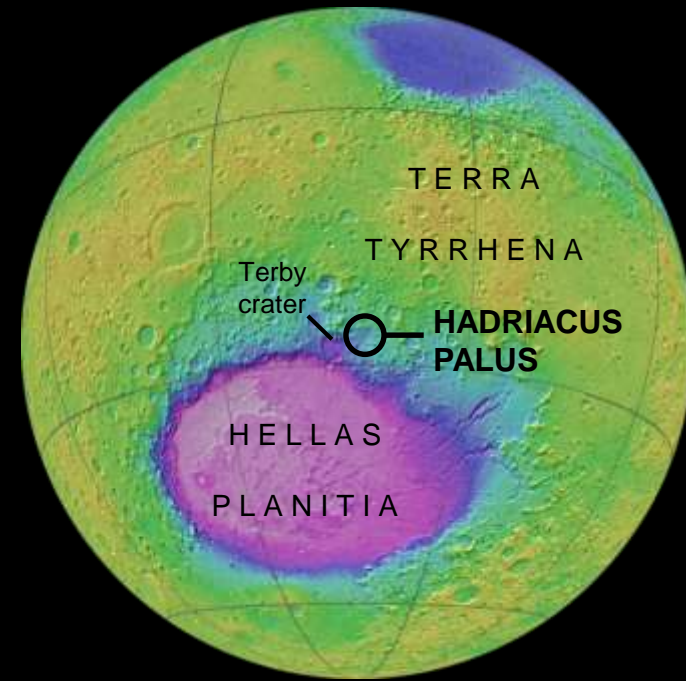
¹USGS Astrogeology Science Center; ²Freie Universität Berlin, Planetary Science Institute³

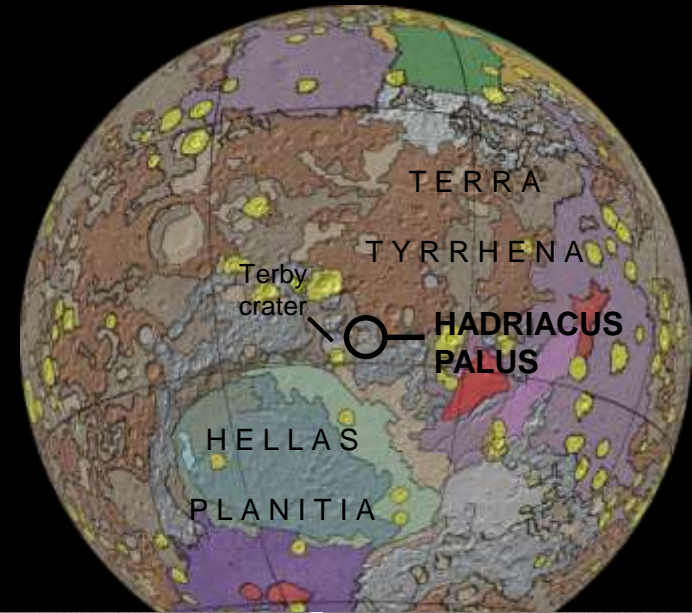
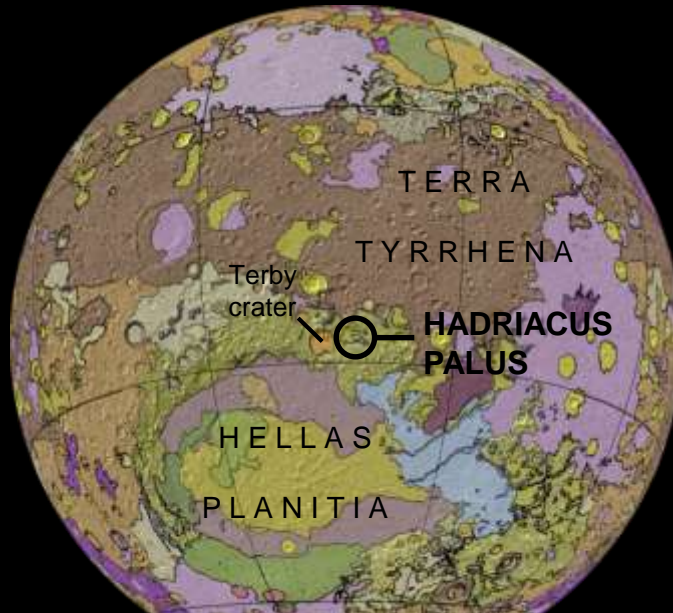
w/ C. Edwards (CRISM) and L. Edgar (local mapping)

Why Hadriacus Palus?

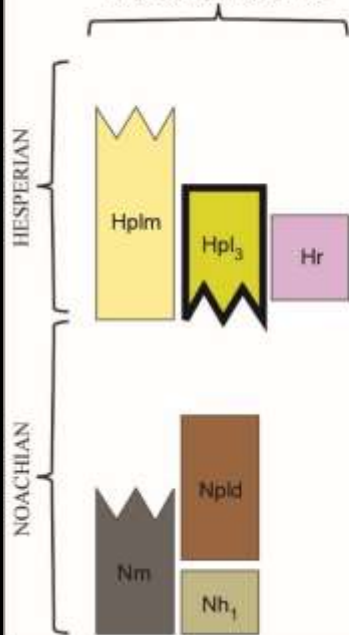
- Land on and go-to science
- **Excellent contextual geology**
- Exhumed Noachian **extensional basin** sequence
- Lacustrine, fluvial, playa (?), and volcanic outcrops
- Adjacent to uplifted crustal massifs
- **Representative** highland plains units
- 2 channel systems, **different provenance**
- 30 m - >100 m exposed and **accessible strata**
- High likelihood basement and volcanic rock
- Fracture sets pervasive
- Fe/Mg phyllo minerals**

Site Name	Hadriacus Palus
Center Coordinates	-26.910°N, 78.017°E
Elevation (MOLA)	-2624.8 ± 38.2 m
Slope (MOLA)	0.7 ± 0.6°
Ellipse size	17 x 14 (nominal)
Prime Science Targets	Stratified units Channels (2) Subaqueous sediments Igneous rocks/sediments

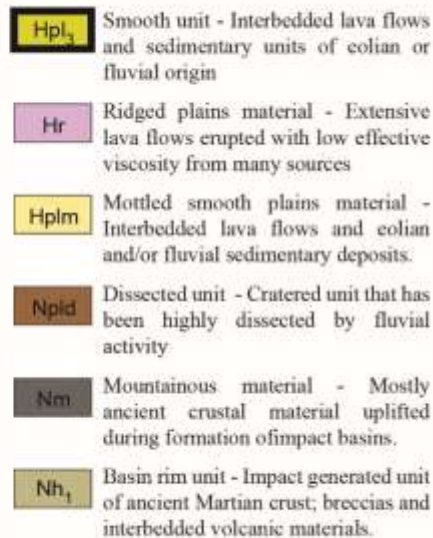




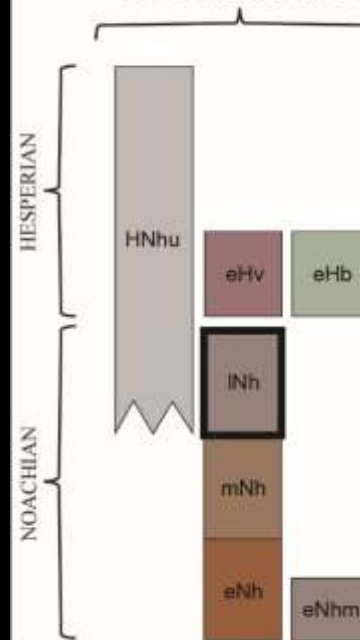
HIGHLAND AND CIRCUM-HELLAS GEOLOGIC PROVINCE



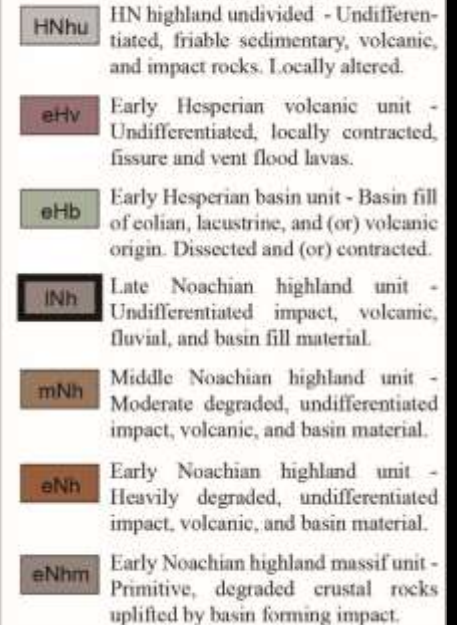
USGS I-1802 (VIKING ORBITER) INTERPRETATIONS



HIGHLAND AND CIRCUM-HELLAS GEOLOGIC PROVINCE

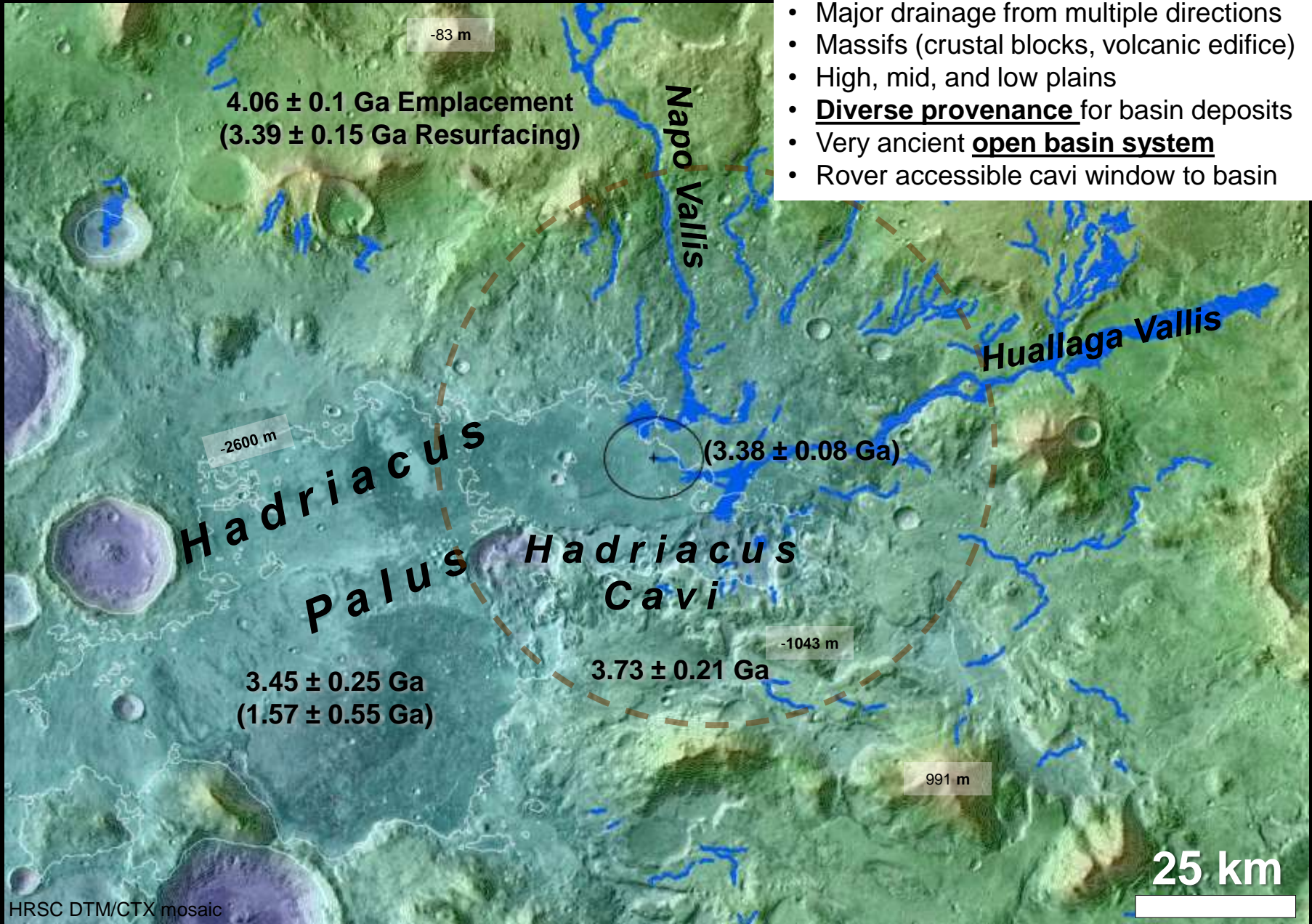


USGS SIM 3292 (POST VIKING ORBITER) INTERPRETATIONS



Regional Setting

- Ovoid 160 km x 80 km
- Noachian to Hesperian terrains dominate
- Major drainage from multiple directions
- Massifs (crustal blocks, volcanic edifice)
- High, mid, and low plains
- **Diverse provenance** for basin deposits
- Very ancient **open basin system**
- Rover accessible cavi window to basin



Data Coverage

CTX – 100% of the ellipse

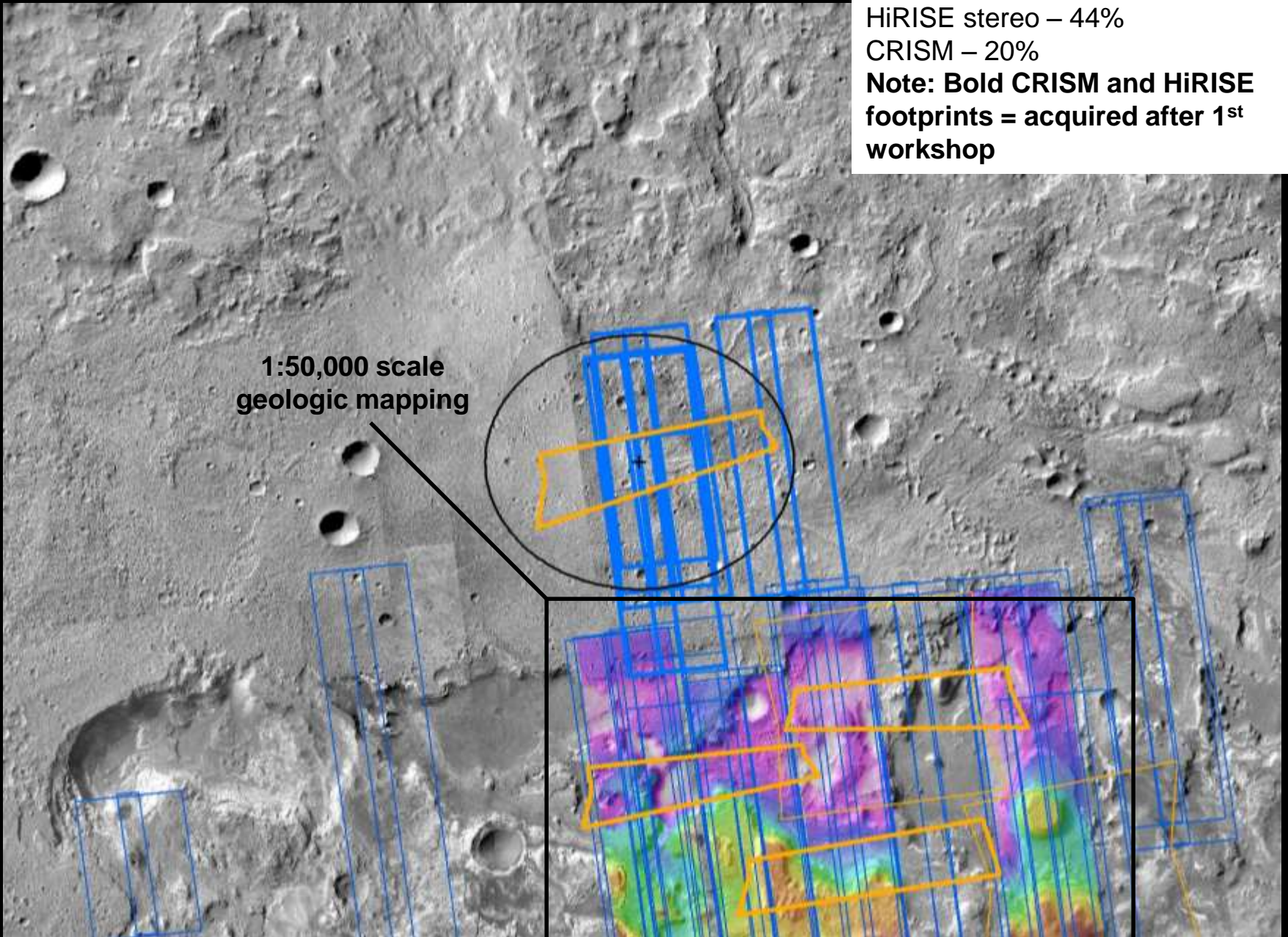
HiRISE – 58%

HiRISE stereo – 44%

CRISM – 20%

**Note: Bold CRISM and HiRISE
footprints = acquired after 1st
workshop**

1:50,000 scale
geologic mapping

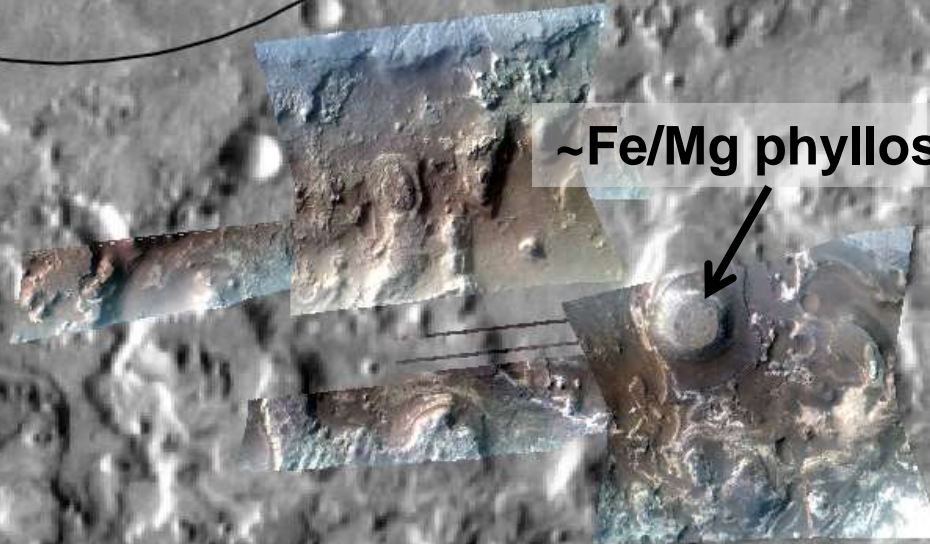
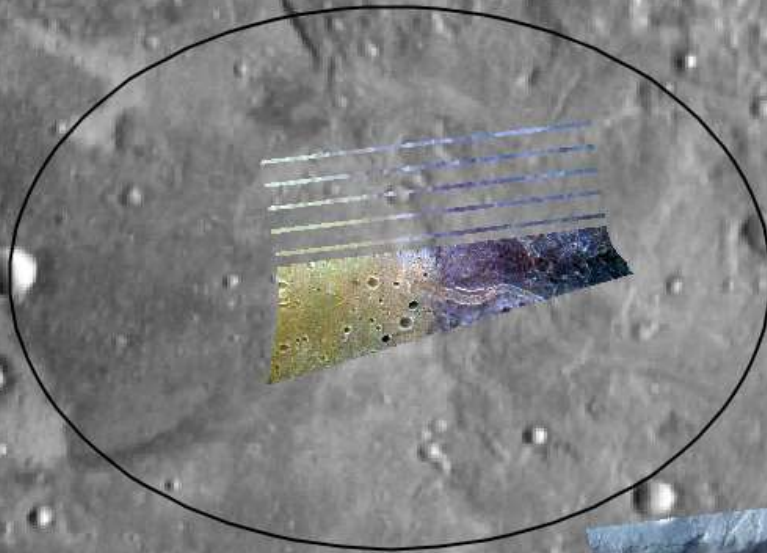


3 Band Color (stretched)

R:2.53 μ m; G:1.51 μ m; B:1.08 μ m

→ Mafic background

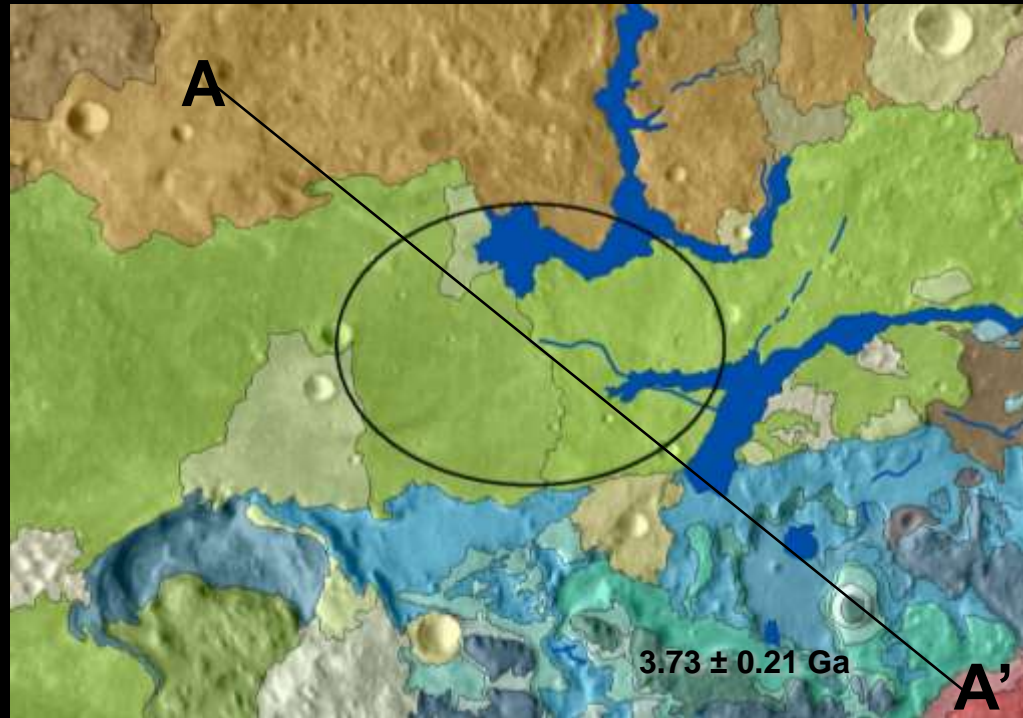
→ Good for 1:50K map



~Fe/Mg phyllosilicate

10 km









Geologic History

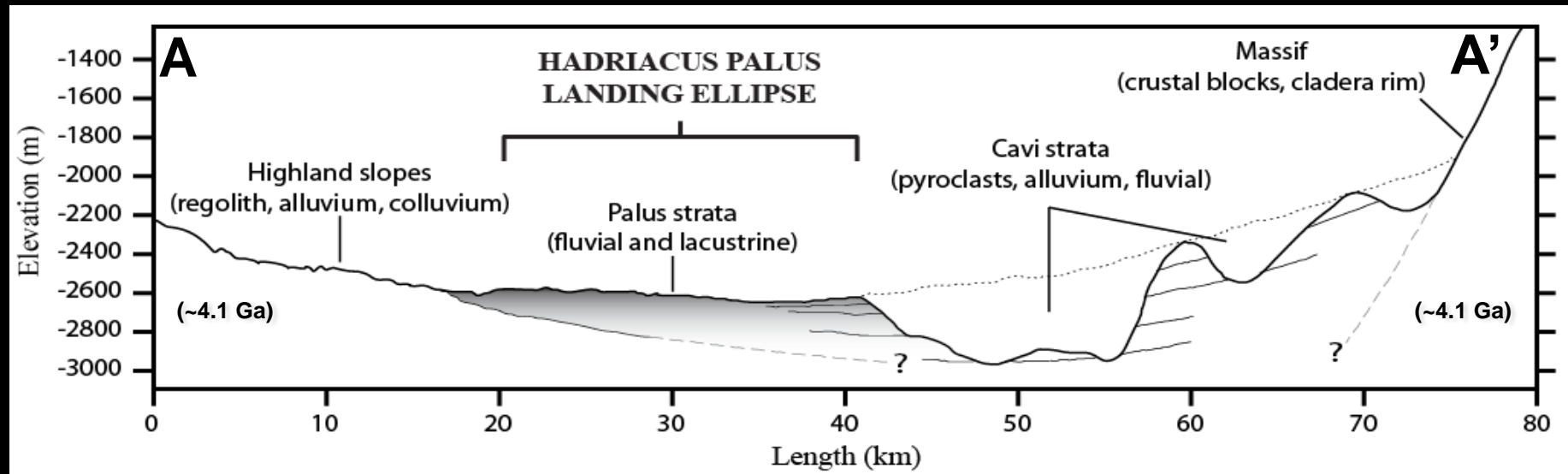


Basin sequences thickening southward

- Pre-Noachian (?) massifs
- E. Noachian highland slopes
- Cavi strata spans Noachian – Hesperian
- E. to L. Hesperian (?) channels
- E. to L. Hesperian lake/playa (?)
- Emplacement and exhumation**

Record of representative highland basin

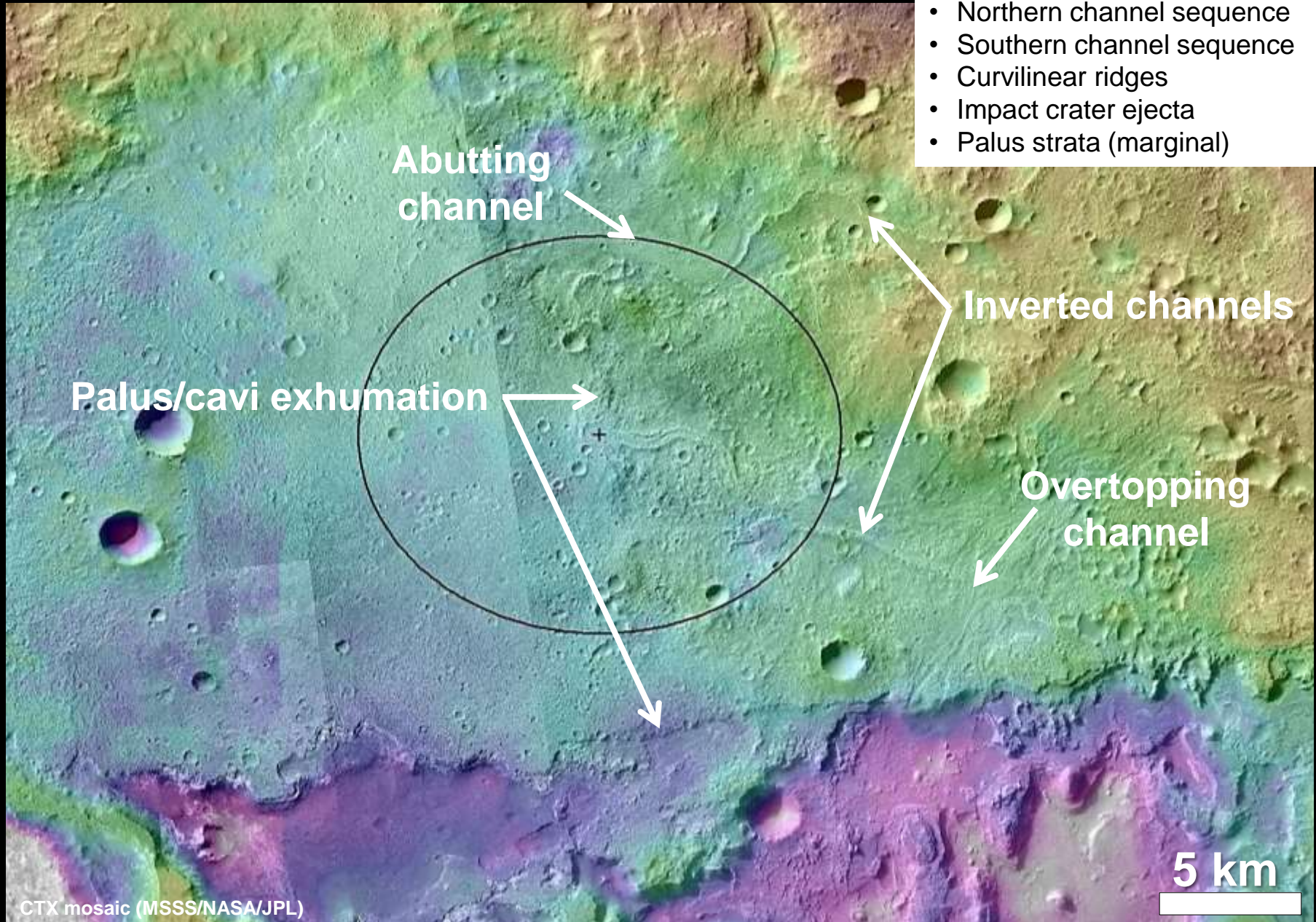
	Cavi material		Crater material
	Highland slope material		Palus units
	Highland material		Channel and fan material
	Massif material		Stratified material



Science Potential via ROIs

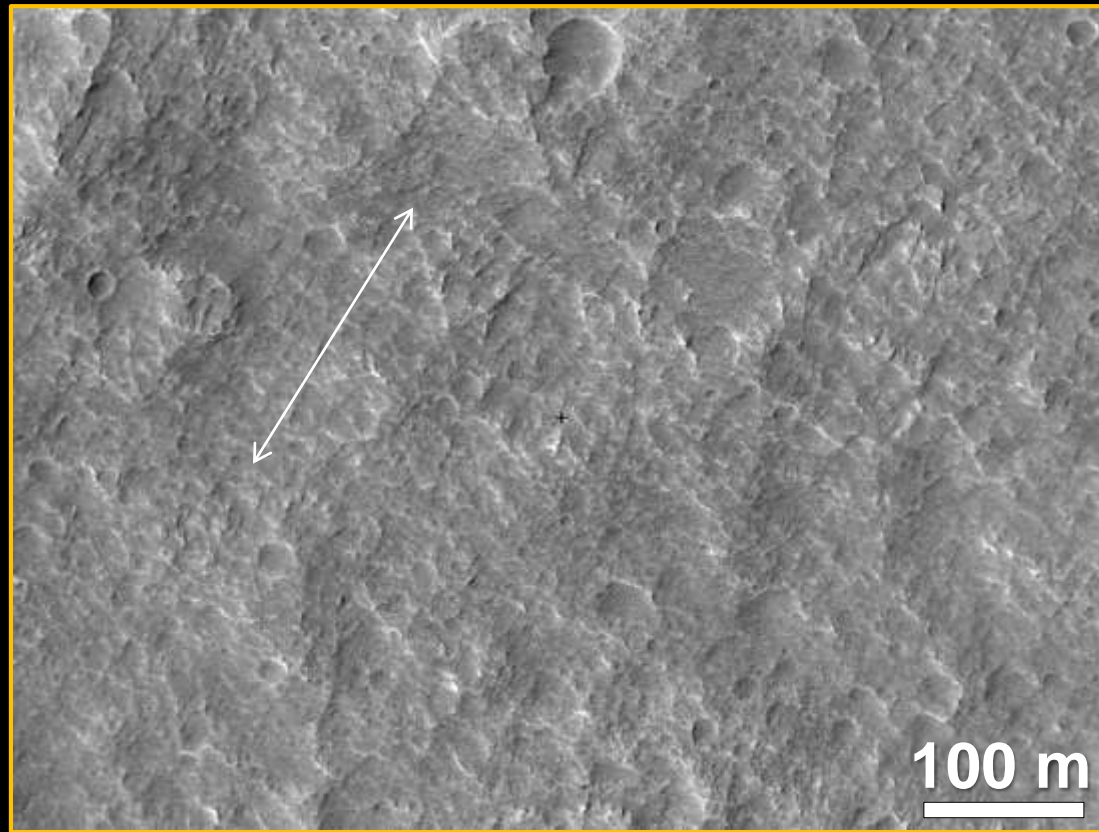
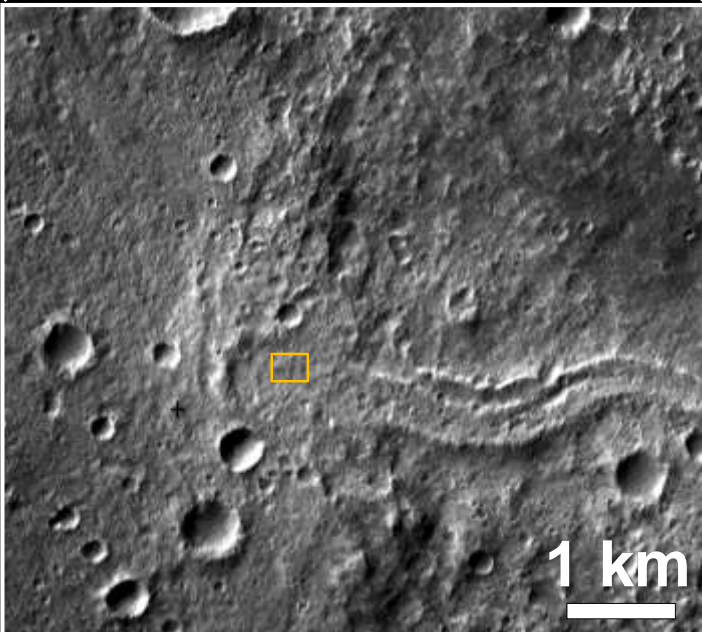
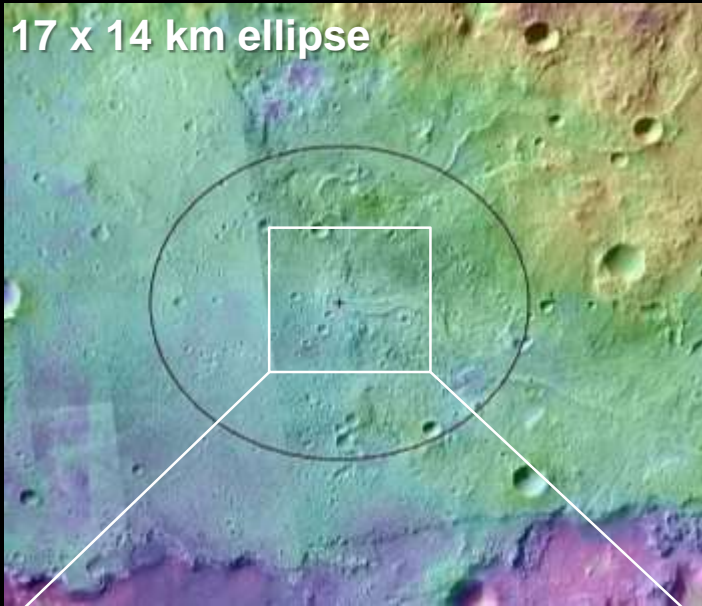
Exploration Goals:

- Palus strata (center)
- Northern channel sequence
- Southern channel sequence
- Curvilinear ridges
- Impact crater ejecta
- Palus strata (marginal)



Landing Site (0 km)

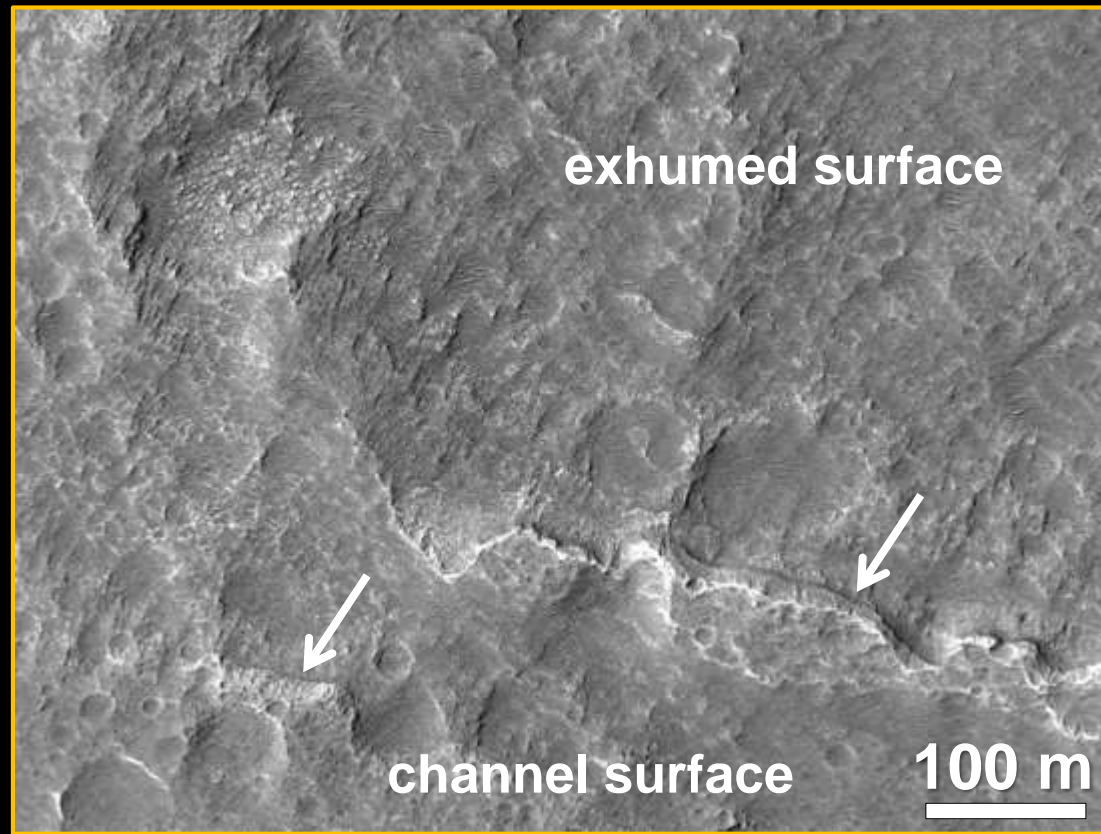
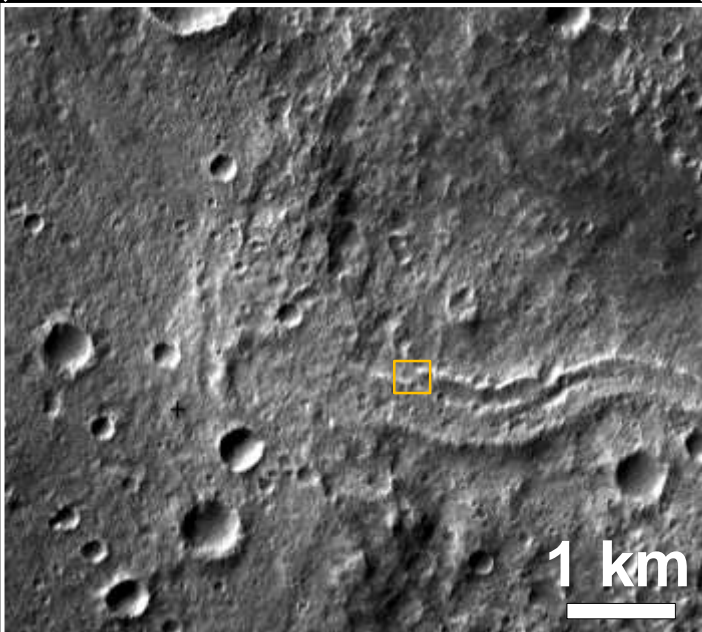
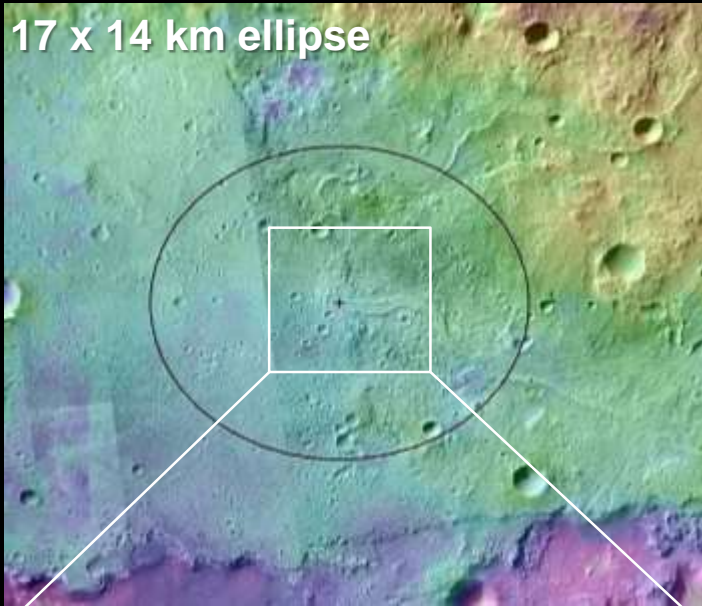
17 x 14 km ellipse



- Early to Late Hesperian surface
- Termination of inverted channel
 - *Southern channel sequence*
- Boulder-free, dune-free surface
- ~5-10 m scale polygonal fracturing
 - *Eroded into "cusate" surface*
 - *Pervasive throughout surface, section*
 - *Resistant "cap rock" ... similar to channel surface*

Southern channel (1.4 km)

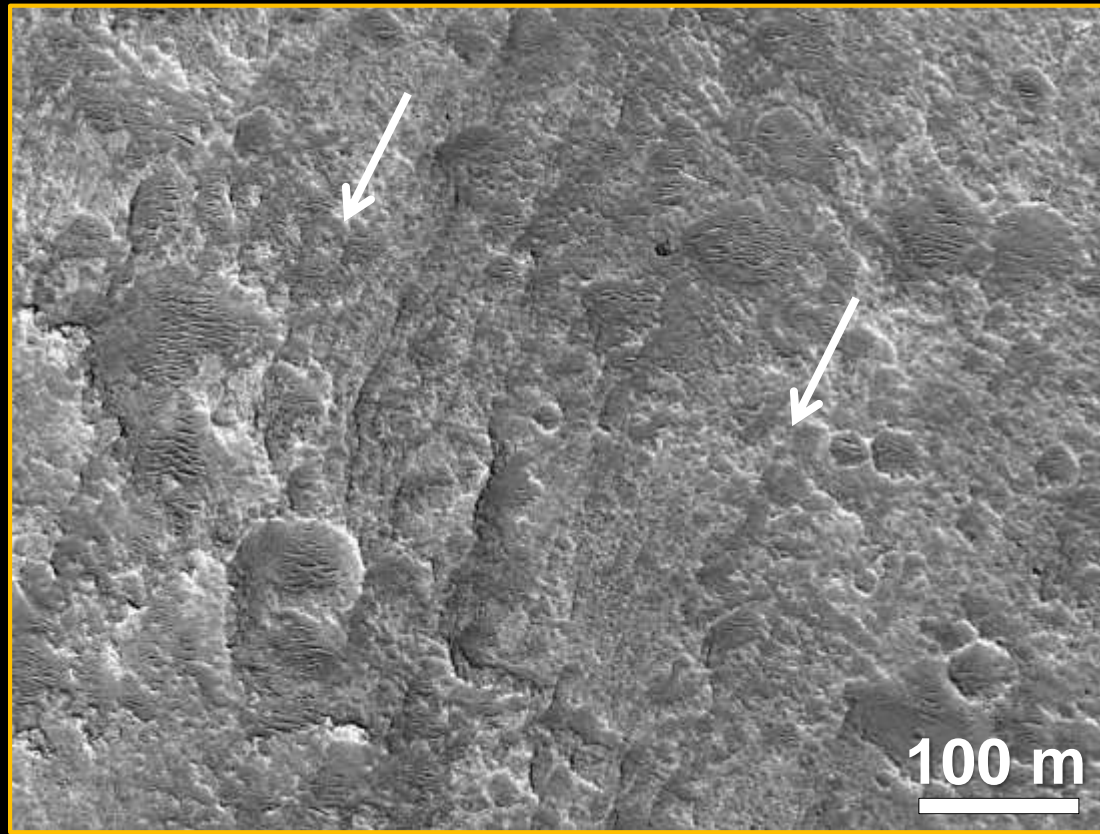
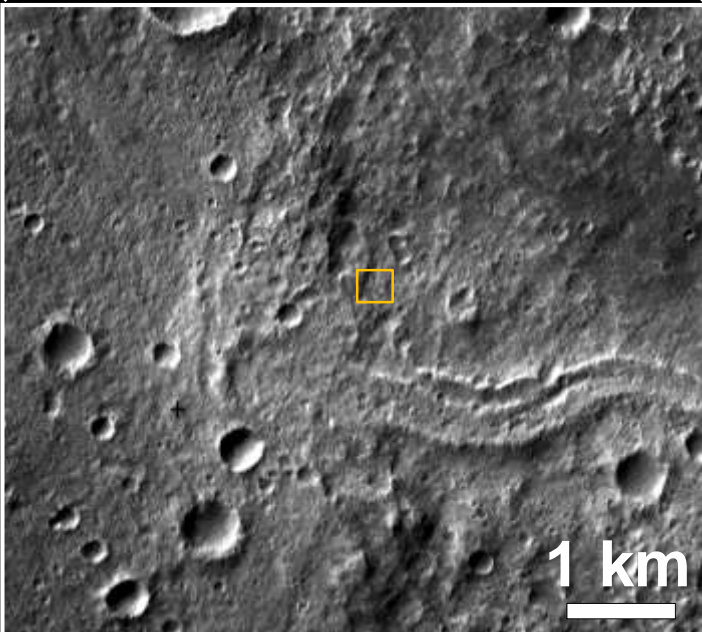
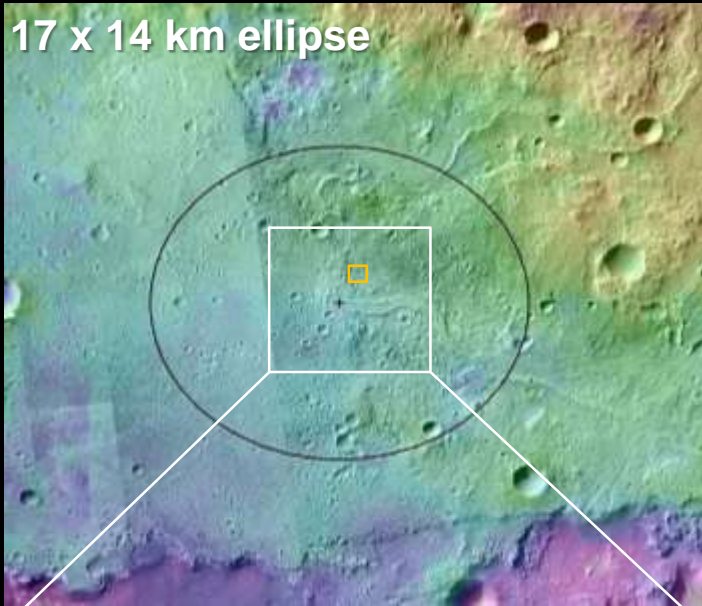
17 x 14 km ellipse



- Inverted channel margin(s) - *white arrows*
 - *Top most resistant "cap-rock"*
- Thin beds over polygonal/brecciated unit
 - *Common along palus scarp*
 - *~8-10 m*
- Low energy fluvial/ high energy fluvial?
- Channel inversion mystery

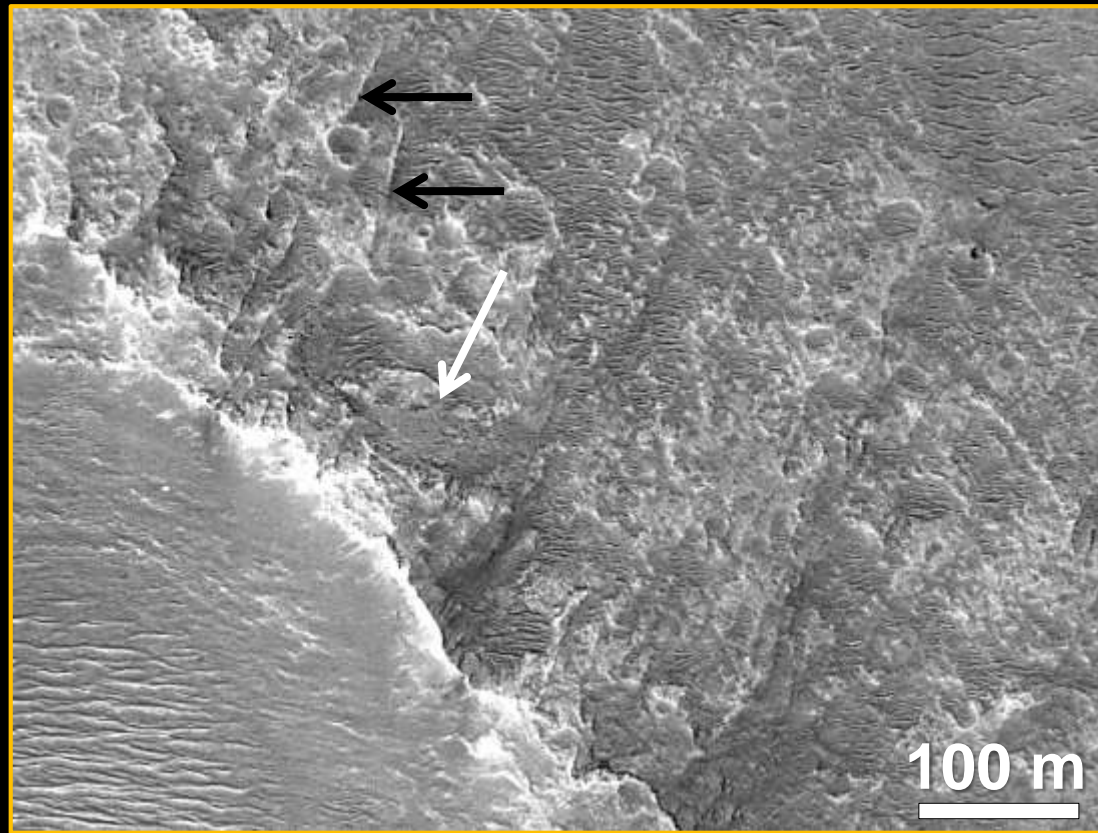
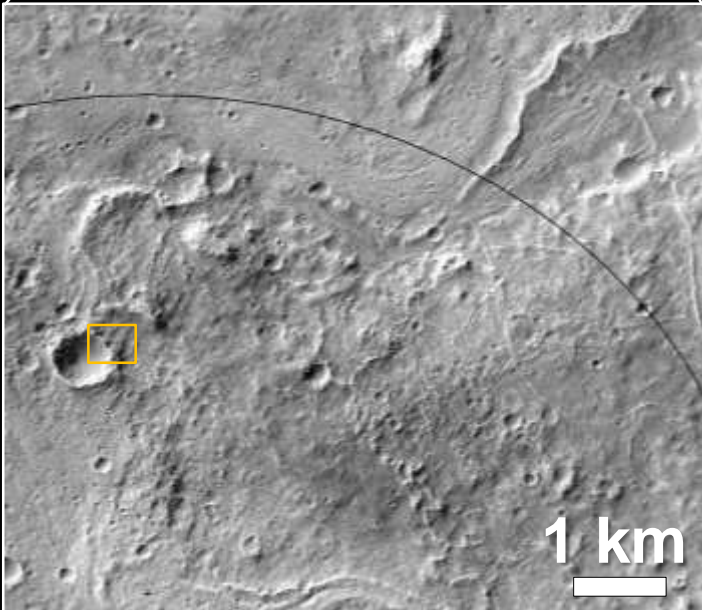
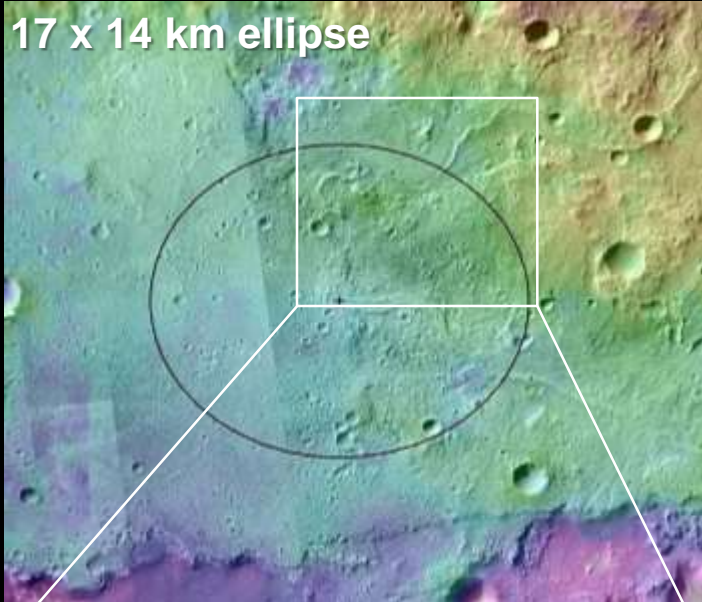
Palus Margin (1.9 km)

17 x 14 km ellipse



- Thinly-bedded strata (~20 over ~4-5 m)
 - 20 cm thickness (ish)
- Boulder-free, some dunes, sand
- Lacustrine (?) or playa-like environment
 - Horizontality, thinness of beds
 - Pervasive "polygonal" fractures

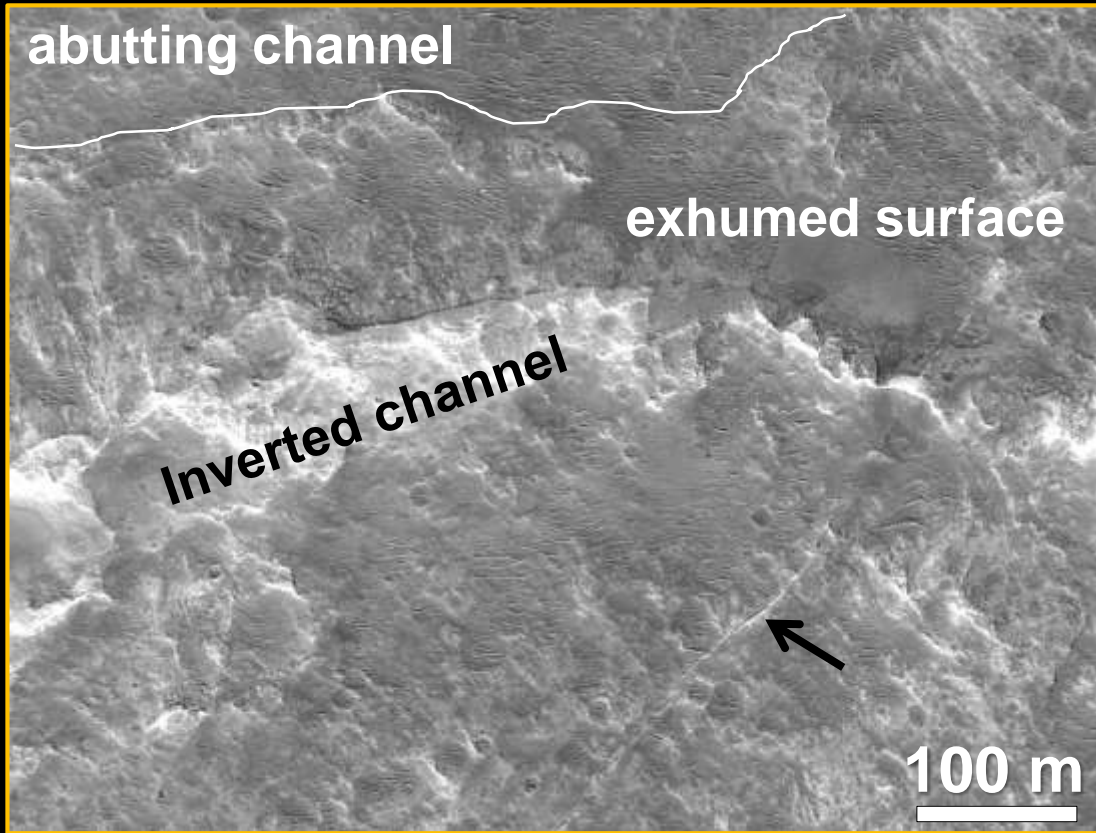
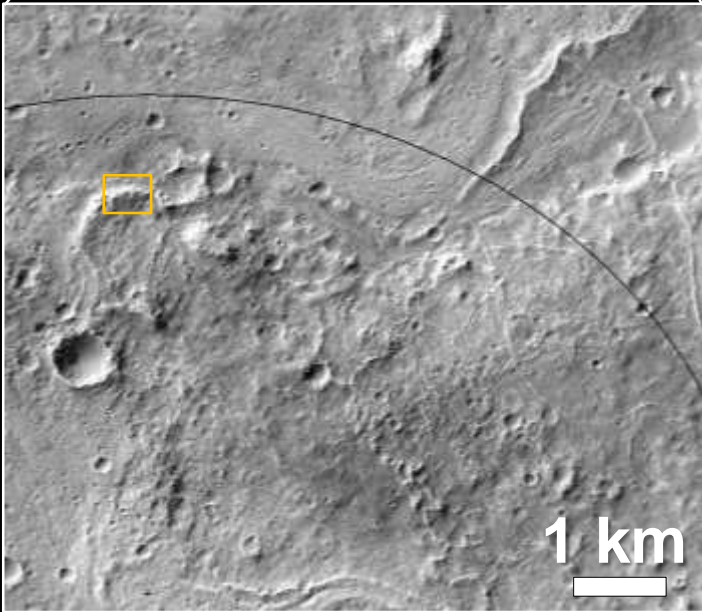
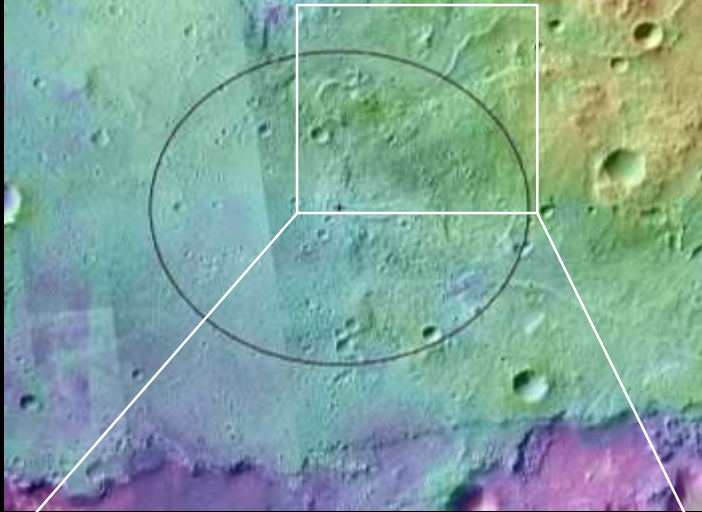
Crater ejecta (3.5 km)



- ~800 m impact crater
- Superposes palus, northern channel (LH?)
- Exposes resistant cap-rock, strata
- Dune-filled, but marginal ejecta, melt (?)
 - *Lineations, some boulders*
 - *Smooth draping unit (white arrow)*
- *Curvilinear ridges (black arrows)*
 - *Common on exhumed palus surface*

Northern channel (5.5 km)

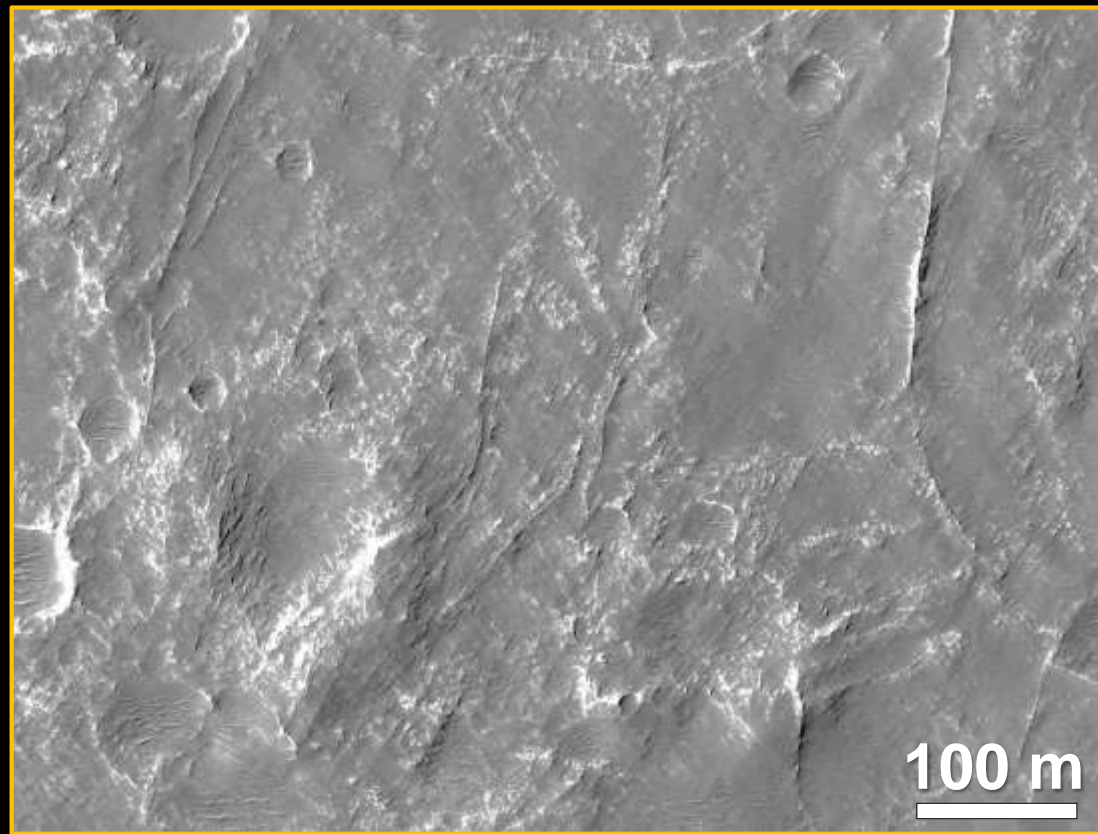
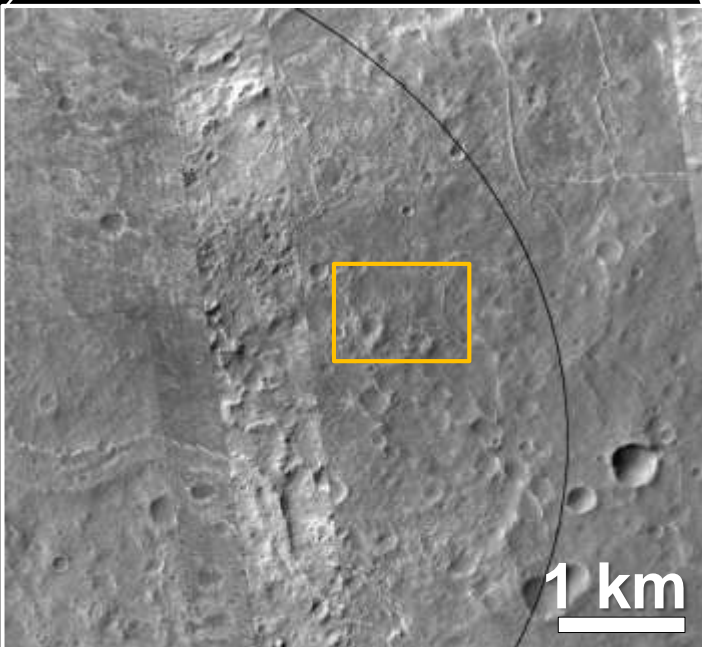
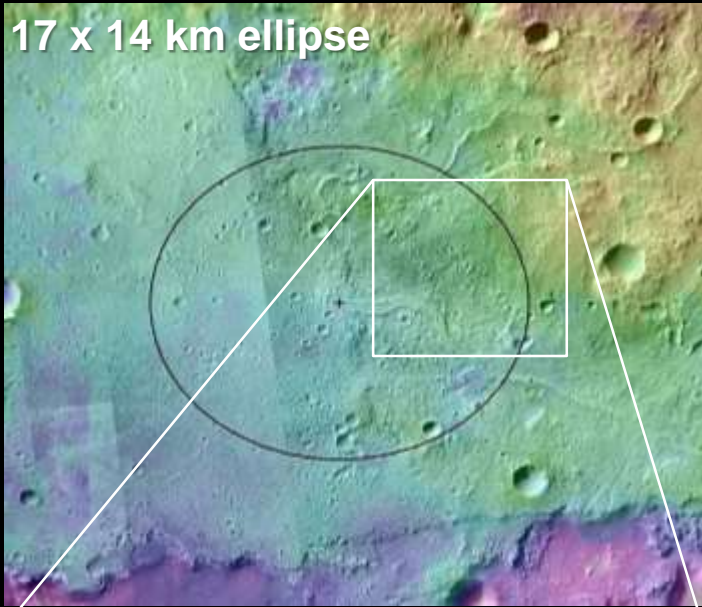
17 x 14 km ellipse



- Northern channel “sequence”
 - *Cap-rock, thin beds, polygonal/brecciated unit*
 - *Abutting channel via Napo Vallis (northern watershed)*
- Curvilinear ridges (black arrow)
- Local temporal sequence
 - *Low energy fluvial into lake/playa*
 - *Tensile fracturing, mineralization*
 - *Exhumation*
 - *High energy fluvial into playa/lake*

Curvilinear ridges (6.5 km)

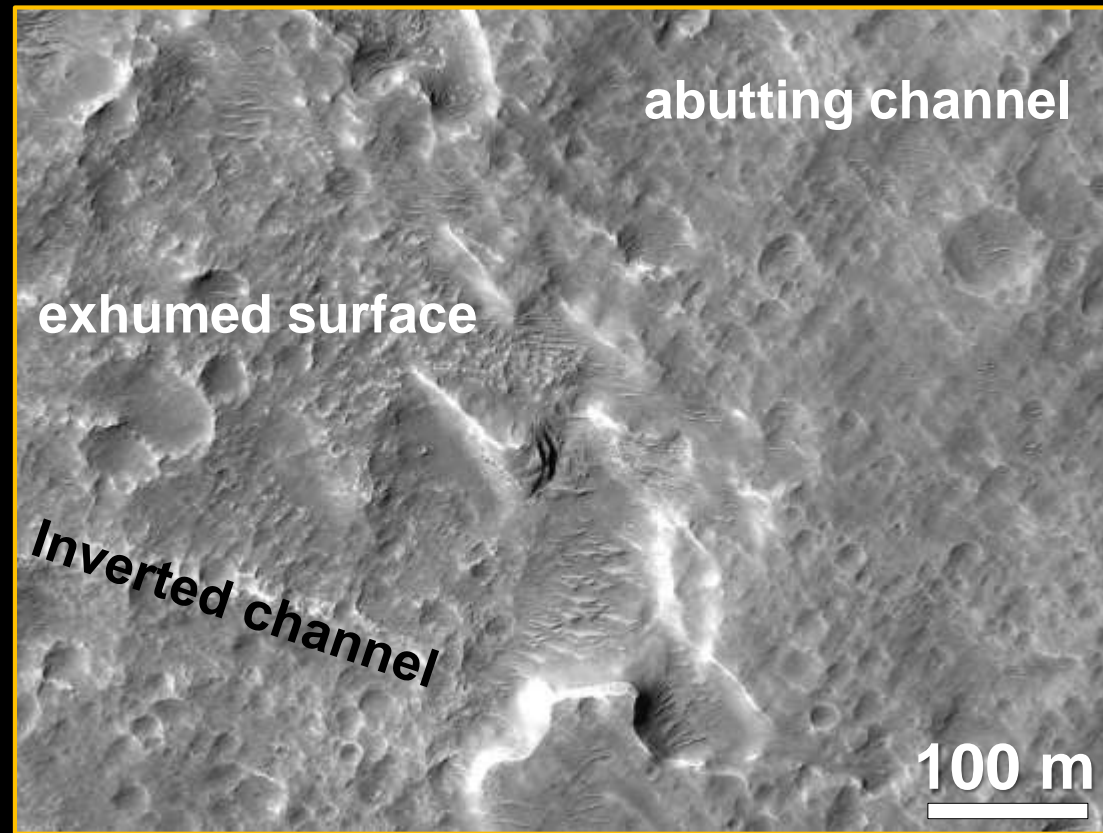
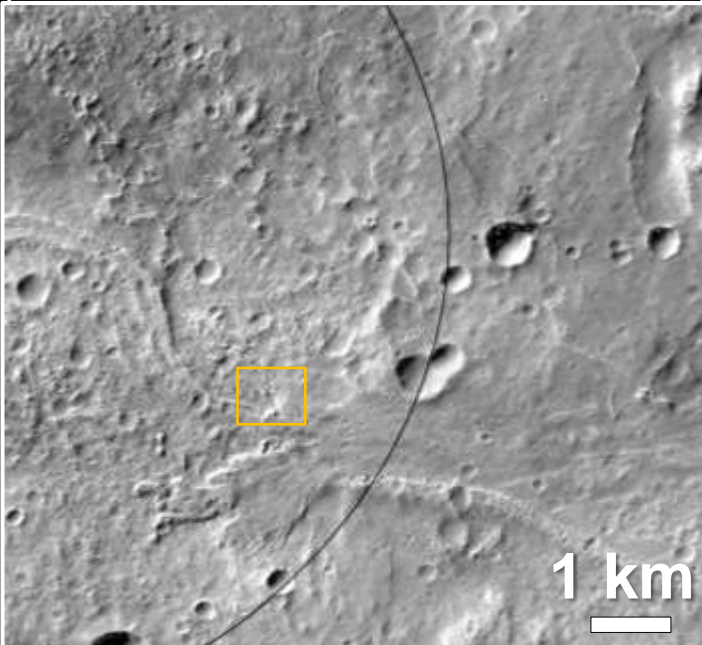
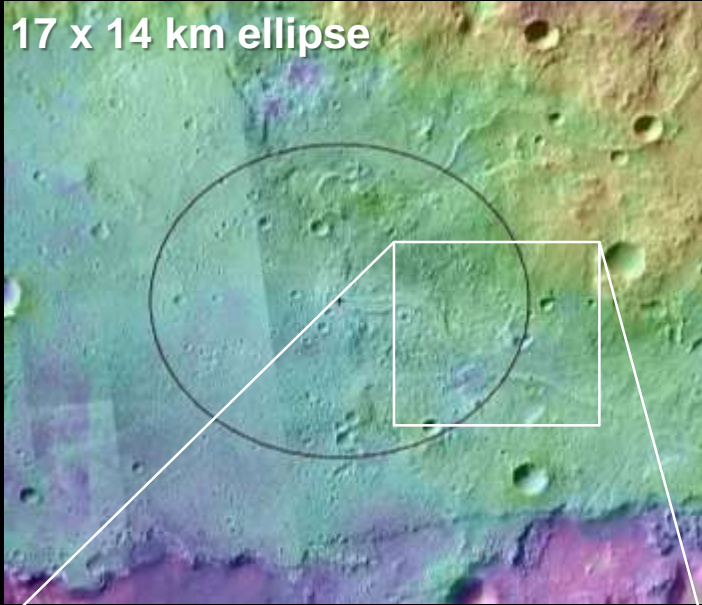
17 x 14 km ellipse



- Pervasive curvilinear ridges
 - *Few meters across, few meters high*
 - *Form quasi-rectangular “polygons” ~1 km across*
 - *N-S and E-W orientation, though variable*
- Mineralization of planar voids
 - *Extension (~ structures in cavi)*
 - *Groundwater, hydrothermal (?)*

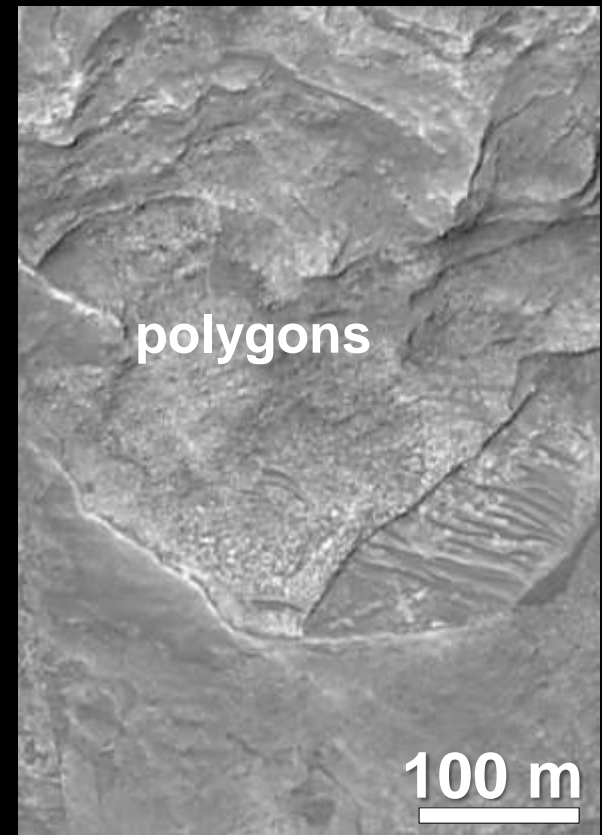
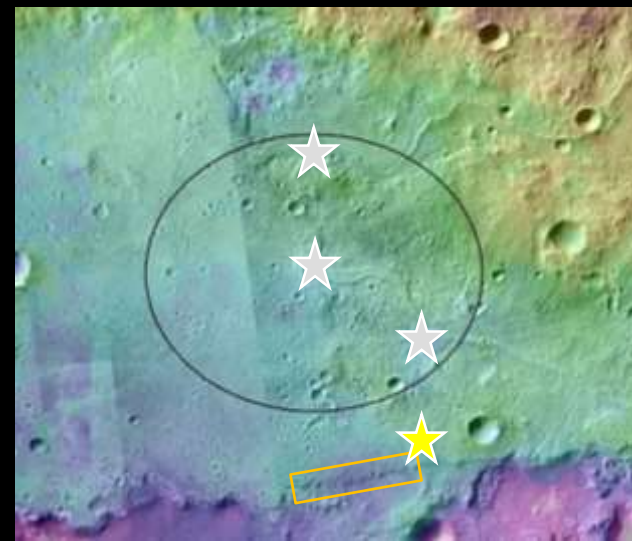
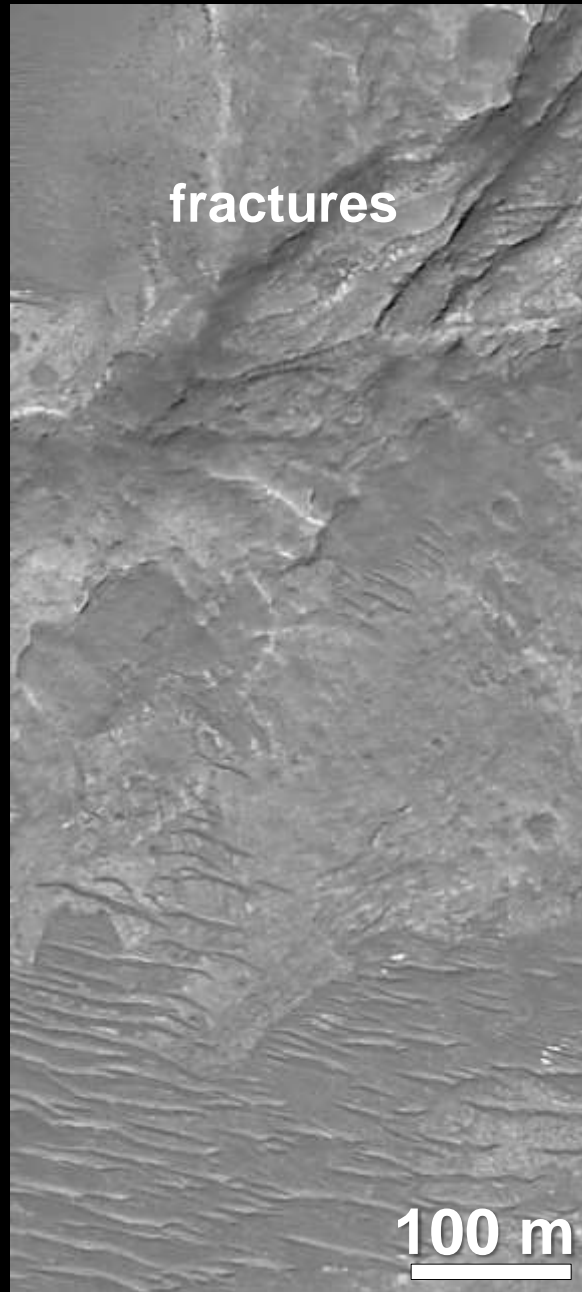
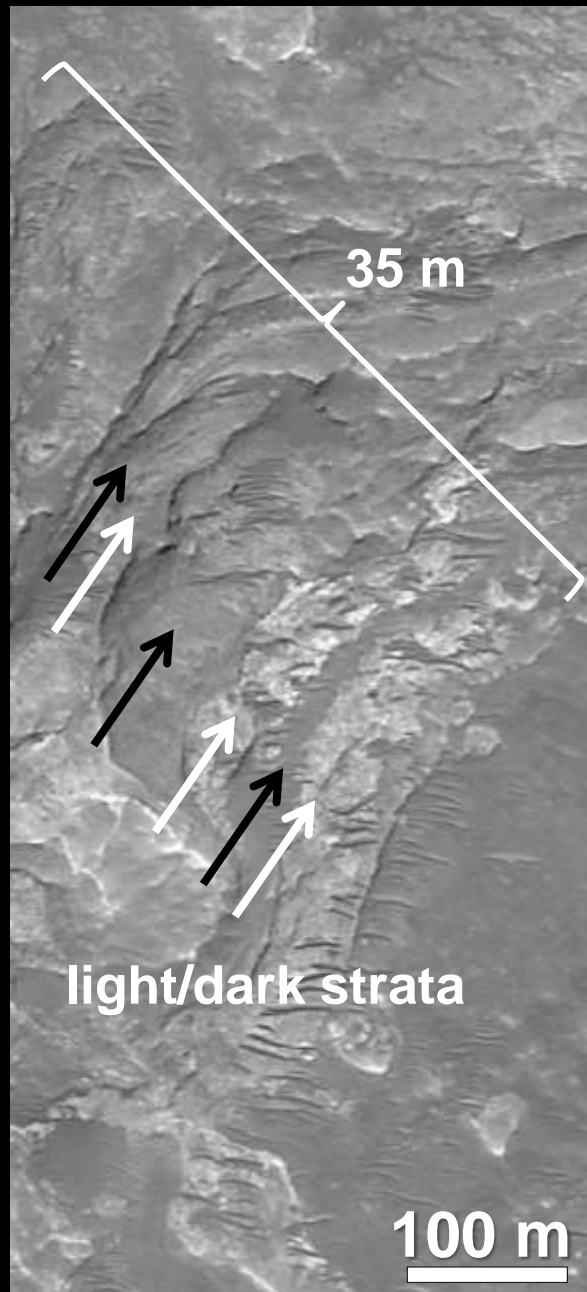
Southern channel (6.1 km)

17 x 14 km ellipse



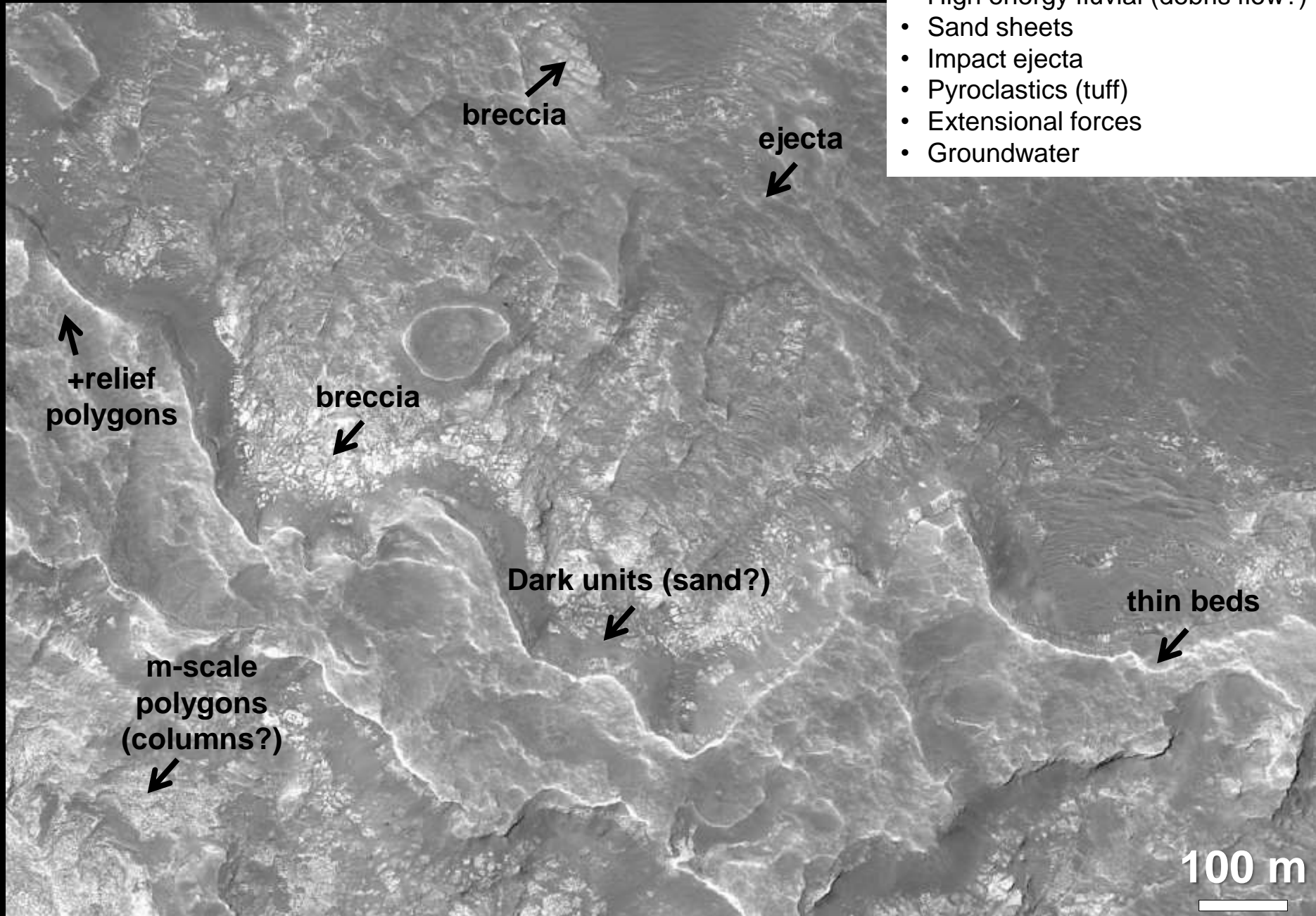
- Southern channel "sequence"
 - *Cap-rock, thin beds, polygonal/brecciated unit*
 - *Abutting/overtopping channel via Huallaga Vallis (eastern watershed)*
- Local temporal sequence
 - *Low energy fluvial into lake/playa*
 - *Tensile fracturing, mineralization*
 - *Exhumation*
 - *High energy fluvial into playa/lake*
 - *Exhumation*

Palus southern margin (10-11 km)



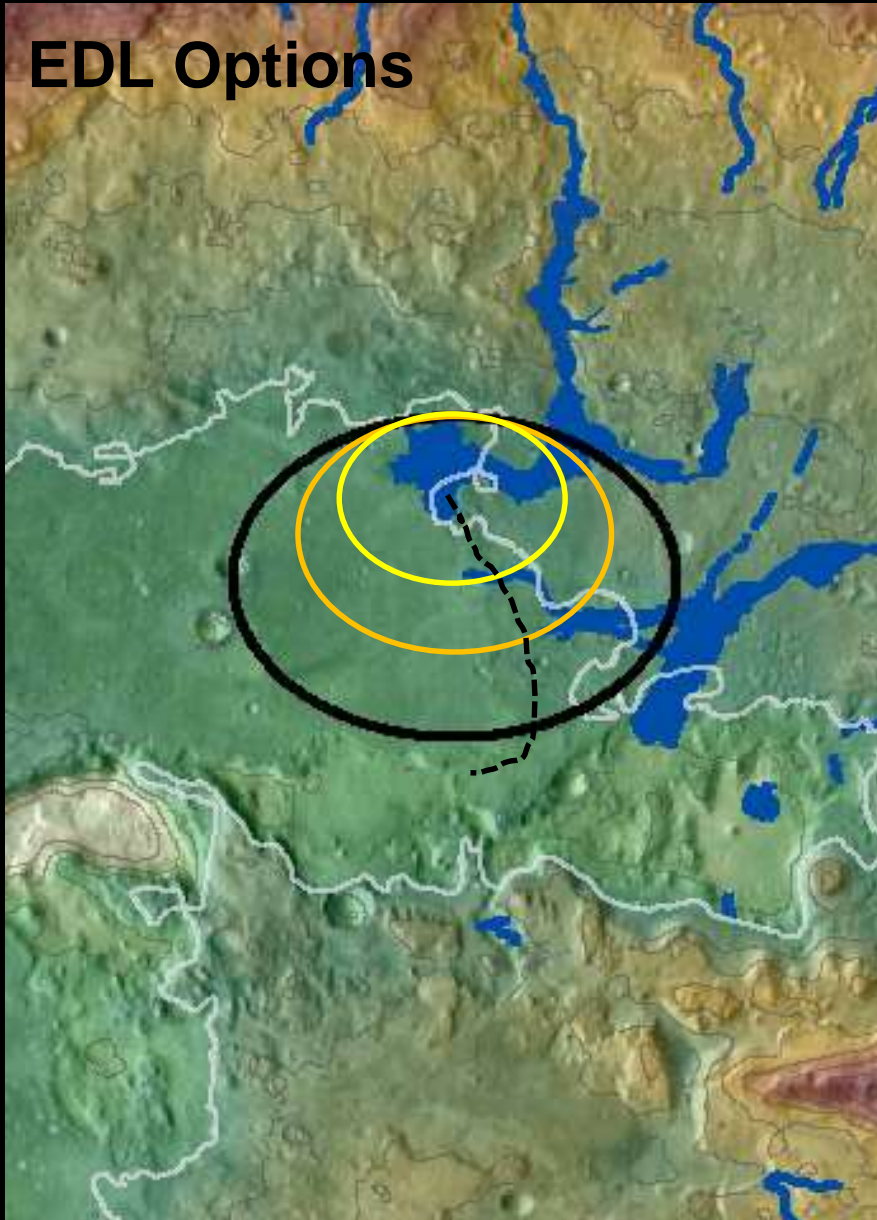
Palus southern margin (~12 km)

- Low energy fluvial/lacustrine
- High energy fluvial (debris flow?)
- Sand sheets
- Impact ejecta
- Pyroclastics (tuff)
- Extensional forces
- Groundwater



Engineering Constraints

EDL Options



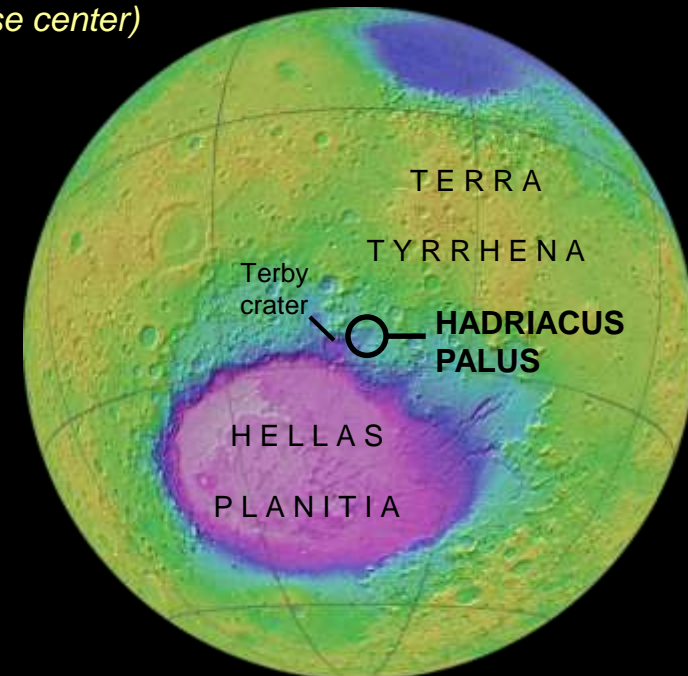
- Land on and go-to site
- 17 x 14 km ellipse (can shift)
- RT and +TRN (useful, not critical)
 - *Avoid local impact craters*
 - *More specified target*
 - *Hazard avoidance*
 - *Efficient pre-plan of traverse envelope*
- Traverse conditions favorable

Constraint	
Elevation below +0.5 km MOLA	✓
Latitude $\pm 30^\circ$ of the equator	✓
Landing ellipse, nominal (25 km x 20 km)	✓
Landing ellipse, range trigger (18 km x 14 km)	✓
<100 m relief at 1 to 1,000 m baseline lengths	✓
<25 – 30 slopes at 2-5 m baseline lengths	?
Rock abundance and height/occurrence probability	?
Radar reflectivity >-20 dB and <+15 dB at Ka band	?
Load bearing surface: $TI > 100 \text{ J m}^{-2} \text{ K}^{-1} \text{ s}^{-\frac{1}{2}}$	✓
Load bearing surface: Albedo <0.25	✓

Summary - Hadriacus Palus

Immediate access to diverse, contextual geological units

- **Representative section** of Martian intercrater plains
 - *Regional and local geology fairly well constrained (evolving)*
- **Land on Science**
 - *Basin formation and filling processes*
 - *Fluvial and lacustrine infill (~10-12 m within 6 km of ellipse center)*
 - *Diverse provenance (EN Hellas massifs, highland volcanics, dissected regolith)*
 - *Exhumation and infill (multiple times)*
 - *Mineralized fractures*
- **Go to Science**
 - *Traverse across Noachian-Hesperian boundary*
 - *Down basin → Down traverse (100 m section <15 km from ellipse center)*
- **Important science issues to be resolved**
 - *Lacustrine and fluvial environment (MN → H)*
 - *Crustal formation (bounding massifs)*
 - *Igneous processes (?)*
 - *Basin filling processes*
 - *Channel sequencing and inversion*
 - *Alteration processes (filled fractures)*
 - *Syn- and post-tectonic sedimentation*
- **Satisfies Science and Engineering**
- **Not well established**
 - *Direct evidence of aqueous geochemistry*
 - *Volcanic units on palus surface*
 - *Diversity of bounding terrains*



Landing Site Factor	Mars 2020 Mission and Decadal Priority Science Factors																							
	Environmental Setting for Biosignature Preservation and Taphonomy of Organics								Type 1A & 1B Samples: Aqueous Geochemical Environments indicated by Mineral Assemblages								Type 2 Samples: Igneous		Context: Martian History Sampled, Timing Constraints					
	Deltaic or Lacustrine (perennial)	Lacustrine (evaporitic)	Hydrothermal (<100°C) surface	Hydrothermal (<100°C) subsurface	Pedogenic	Fluvial/Alluvial	No diagenetic overprinting	Recent exposure	Crustal phyllosilicates	Sedimentary clays	Al clays in stratigraphy	Carbonate units	Chloride sediments	Sulfate sediments	Acid sulfate units	Silica deposits	Ferric Ox./Ferrous clays	Igneous unit (e.g, lava flow, pyroclastic, intrusive)	2nd Igneous unit	Pre- or Early-Noachian Megabreccia	Oldest stratigraphic constraint	Youngest stratigraphic constraint	Stratigraphy of units well-defined	Dateable surface, volcanic (unmodified crater SFD)
	~	●	~	~		●		~	○									~		●	LN	LH	●	

Thin beds and polygons: Strong evidence for quiescent deposition into (shallow?) standing body of water and/or playa; some evidence for desiccation

Curvilinear ridges: Evidence for – unclear process of – subsurface fluid flow

Channels: Diverse channel forms indicate variable activity (meandering to debris flows)

Scarp retreat: Strong evidence for ongoing exhumation in cavi (outside ellipse); moderate evidence for similar exhumation on palus surface

Fe/Mg phyllosilicates: Strong evidence in circular mesa well outside of ellipse; potentially correlative along palus margin (tenuous)

Provenance, columnar joints: Evidence volcanic material in watershed; accessible volcanic (tuffaceous) unit

Adjacency of uplifted crustal massifs: Elevated potential for ancient rocks in section

SFD model absolute ages: Fairly well fits to model ages